Suicide, Sentiment and Crisis.

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Abstract

There is an extensive body of empirical work investigating the relationship between the upswings and downswings of the economic cycle and suicide rates. They are emphatically not typically empirically supportive of the prosperity-induced suicide uplift dimension. This lack of clarity pertains to the precise nature of the transmission mechanism by which an economic crisis actually affects suicide. This study posits the hypothesis that this influence broadly translates as emotional reaction, 'gut feelings' and as such explicitly considers the use of subjective factors of economic performance to better explain variations in suicide rates. Alongside traditional economic indicators we use a 'consumer sentiment' measure, a sense of how economic factors are *perceived* to be impacting on individuals, to explain suicide rates. Furthermore, we explicitly consider the impact of the global financial crisis and test the impact of state public and health expenditures. Results show that consumer sentiment is found to offer a significantly greater explanatory role in exploring variations in the suicide rate compared to traditional economic indicators. Moreover, the effect of consumer sentiment is greater for females than for males, with some nuances in explaining this result. State public and health expenditures do not seem to have any significant influence on suicide rates.

Key words: suicide, USA, consumer sentiment, financial crisis

1. Introduction

Pierce (1967) explores a number of passages from Durkheim's seminal 1897 study to consider the dimensions of "anomic suicide" in both upswings and downswings of the economic cycle. He finds that,

> "Durkheim is maintaining...that the factor elevating suicide rates is the relative state of disorganization induced by rapid economic change and that those rates are tempered by economic stability-regardless of the levels of economic activity. Even more striking is his claim that the direction of the change is of no consequence." (p458)

For Pierce (1967) a suitable test of Durkheim's hypothesis requires an investigation of the relationship between some measure of economic change and suicide rates, presumably along the lines of the statistical analyses of Antonakakis & Collins (2014, 2015). Even though that work and many others in a similar vein (see, for example, the extensive body of empirical work surveyed in Chen et al. 2012) are typically supportive of the crisis-induced suicide uplift dimension of 'anomic suicide', they are emphatically not typically empirically supportive of the prosperity-induced suicide uplift dimension. Some movement towards an empirical reconciliation of this body of work with Durkheim's central hypothesis, however, emerges in Antonakakis & Collins (2018). They find that the suicide-economic growth (income) relationship over 73 countries is 'N' shaped, such that increasing male suicide rates can be observed in more prosperous advanced developed countries. They can only speculate that this may be due to factors such as, work-life balance concerns, arduous commuting, peer group pressures and potentially status anxieties.

Given the speculative nature of the explanation, there is, evidently, a remaining lack of clarity in such empirical work. This lack of clarity pertains to the precise nature of the transmission

mechanism by which any crisis actually affects suicide. As Durkheim himself questions of the process - What do these crises owe their influence? [p242].

This study posits the hypothesis that this influence broadly translates as emotional reaction, 'gut feelings', or, as is more formally measured - 'consumer sentiment'. Harnessing the concept, it is then possible to consider more robustly a range of contemporary sociological and social policy questions. For example, has the most recent global financial crisis increased the suicide rate in the USA and have higher mental health expenditures in some states helped mitigate the effects of this crisis? While there has been much empirical work exploring suicide mortality in the USA, more recent economic shocks and high profile policy concerns as suggested by these simple questions have not, hitherto, been subject to rigorous empirical scrutiny.

Earlier work exploring socio-economic determinants of suicide using US state-level data highlight the need to explore economic factors that may generate state-level variations in the suicide rate, such as public health spending. The evidence so far presents a somewhat mixed picture in terms of the range and implications of findings. For example, Minoiu & Rodríguez Andrés (2008) in lieu of mental health spending data indicated that the share of health and welfare in total public spending are strong predictors of suicide rates. For a variety of reasons, their expenditure measure is shown to be highly ambiguous by Ross et al. (2012). They used a more refined measure - per capita public mental health spending - to show that there is insufficient evidence that higher spending will reduce the suicide rate in the United States. Phillips (2013) eschews consideration of mental health spending in an analysis of variations in suicide rates across US states and finds among other significant factors that percentage male population and per capita income are important but that this varied across time and state.

All of these studies do share one common feature: They all rely exclusively on objective measures of economic performance in their model specifications. Despite some exceptions[1], this practice is also commonplace in empirical studies of other social phenomena such as divorce (including, Fernquist, 2003; Härkönen and Dronkers, 2006) and homicide (including, Fajnzylber et al., 2002). Arguably, however, to take explicit account of the transmission process, more subjective economic performance indicators (e.g. indices of economic optimism, the US Consumer Sentiment Index) may well better represent the way people actually perceive their socio-economic situation or expect that situation to unfold. This study directly explores that contention. It also takes account of some key contemporary policy concerns in order to help develop stronger predictive models of suicide rates. This may inform policy communication, resource allocation and policy design directed to the USA's tenth largest cause of death of its citizens (CDC 2015).

The remainder of this study is organised as follows. Section 2 sets out some remarks on the theoretical literature informing this study and sets out the key hypotheses explored. Section 3 describes the sources, nature and dimensions of the data used and the modelling strategy deployed to test the hypotheses. Section 4 discusses the research findings and finally, section 5 concludes and outlines some policy recommendations.

2. Theoretical Considerations and Key Hypotheses

There is a voluminous stock of research exploring the general determinants of suicides in theoretical and empirical terms (see, for example, the works surveyed in Stack, 1982, 2000a, 2000b; Platt, 1984; Chen et al., 2012) and in the specific context of the USA (see, for example, Yang, 1992; Chuang & Huang, 1996; Daly et al., 2013; Phillips, 2013). This study departs from this extant work by positing a pivotal (i) ***direct*** and/or (ii) ***intermediary*** role for subjective

[1] For example, in the context of homicide, see Rosenfeld & Fornango (2007) and Rosenfeld (2009).

individual perception of economic circumstances and sentiment surrounding macroeconomic performance, sometimes also described as 'consumer confidence'. Given the prevalence of this concept in theoretical and empirical analyses in economics (see, for example, Ludvigson, 2004; Barsky et al., 2012; Gausden and Hasan, 2016), finance (see, for example, Fisher and Statman, 2003; Lemmon & Portniaguina, 2006), and psychology (see, for example, Spreng & Page, 2001; Chelminski & Coulter, 2007; Bovi, 2009) it is somewhat surprising that its potential role in exploring variations in suicide rates has not, hitherto, been explicitly explored. If such an intermediary role could be empirically identified, it may well serve as a suitable candidate metric for a Durkheimian transmission mechanism by which actual economic circumstances or crises affect suicide rates.

In terms of other key determinants of suicide, both Durkheim (1897) and Hamermesh & Sos (1974) posit a positive relationship between suicide and age. The latter also posit an inverse relationship with permanent income based on a rationality driven cumulative lifetime utility argument. Using Chen et al. (2012) we set out the economic performance and demographic control variables based on the consensus that can be identified in the existing body of literature. These are set out in Table 1. However, in the specific contexts of global financial crisis in the USA we posit and choose to focus for clarity on our distinct contribution on the following hypotheses:

Hypothesis 1: Higher mental health expenditure reduces suicides.

This basic resource allocation hypothesis is at the heart of the work of Minoiu & Rodríguez Andrés (2008) and the re-investigation by Ross et al. (2012). Looking at specific expenditure opportunities, studies such as Ludwig et al. (2009), show that sales of particular drugs can reduce suicide rates. Yet it should be noted for completeness that there are other empirical studies where results seem to point to the legitimacy of considering the negative version of this

hypothesis that higher mental health spending increases suicides (see, for example, Burgess et al., 2004; Shah et al., 2010; Rajkumar et al., 2013). Explanations that may be posited for the negative version are that many suicides are triggered by social factors and not mental health issues so that more spending on mental health is unwarranted and displaces potentially more effective spending elsewhere.

Hypothesis 2: The onset of the 2007 financial crisis in the USA increased the suicide rate.

Berk et al. (2006) and Knapp (2012) consider the arguments that link suicides with financial problems arising from macroeconomic variables and crises. Many other studies explore the linkages empirically primarily using time-series data sources in a variety of country contexts (see, for example, Reeves et al., 2012; Bernal et al., 2013; Chang et al., 2013; Antonakakis & Collins, 2014, 2015). Beyond these, other studies, such as Tefft (2011) and Ruhm (2015), explore the impact of unemployment on mental health. Specifically, Ruhm (2015) finds that a percentage point increase in unemployment in the USA is estimated to raise suicide mortality by 1.7%. More generally, mental health appears to vary pro-cyclically (Ruhm 2003).

Hypothesis 3: The Consumer Sentiment Index (CSI) scores are inversely related to the suicide rate

The Consumer Sentiment Index quantifies consumers' perceptions of their own financial situation and of the general economy in the near and long term. As such, also informed by Berk et al. (2006), Hypothesis 3 is founded on subjective measures of macroeconomic performance impacting on suicide rates rather than objective measures (e.g. unemployment) as typically used in other studies. The University of Michigan's Survey of Consumers involves a forward-looking question about unemployment, this can be used to measure consumers' beliefs and expectations about future unemployment. Since the actual unemployment rate and beliefs and expectations about future unemployment have different information contents, the consumer

sentiment index should display an incremental predictive power of the suicide rate in the USA. In this regard, Ludvigson (2004) also asserts that some of the variability in consumer sentiment cannot be explained by broad economic aggregates, as the underlying relation can be more complex. It should also be noted that beliefs about future unemployment can be exacerbated by social media, which might drive up the propensity for suicidal behavior.

Figure 1 visualizes our research approach and process, which consists of four intertwined frameworks: A) Aims and objectives, and research questions, B) Expectations and hypotheses, C) Research design, and D) Empirical analysis. This research underpins the suicide risk factors and gatekeepers as the determinants of the suicide rate, with a particular emphasis on subjective socio-economic factors (consumer sentiment and crisis). The solid blue line shows how this research is developed from A) to D). The red dashed line indicates how our research findings feedback to Frameworks A) and B).

– Place Figure 1 here. –

3. Data and Modeling Strategy

Data

Variable definitions and data sources are summarised in Table 1.

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Data on the state suicide rates were gathered from the Center for Disease Control (CDC) WISQARS Injury Mortality Reports. Real per capital personal income was sourced from the Bureau of Economic Analysis. Per capita public welfare expenditures, public health expenditures, population density, net migration, divorce rate, proportion of the population of

non-white background and the whether the state is located in the Rocky Mountain Census Region were retrieved from the U.S. Census Bureau. Information on per capita state mental health agency expenditures was obtained from the National Association of State Mental Health Directors Research Institute. The Bureau of Labor Statistics provided data on the civilian unemployment rate. The number of sunny days in the year is available in Dunn (2008). The post 2007-crisis dummy was created by the authors.

Data on the sentiment of consumers were obtained from the Index of Consumer Sentiment constructed as part of the University of Michigan's Survey of Consumers[2]. The index includes responses to five survey questions:

1. "Would you say that you (and your family living there) are better off or worse off financially than you were a year ago?"
2. "Now looking ahead--do you think that a year from now you (and your family living there) will be better off financially, or worse off, or just about the same as now?"
3. "Now turning to business conditions in the country as a whole--do you think that during the next twelve months we'll have good times financially, or bad times, or what?"
4. "Looking ahead, which would you say is more likely--that in the country as a whole we'll have continuous good times during the next five years or so, or that we will have periods of widespread unemployment or depression, or what?"
5. "About the big things people buy for their homes--such as furniture, a refrigerator, stove, television, and things like that. Generally speaking, do you think now is a good or bad time for people to buy major household items?"

The CSI is used to capture the underlying feeling of economic pressures on an individual that are unlikely to be reflected in measures of unemployment. Indeed, this index is found to be

[2] Index calculations are described by the University of Michigan https://data.sca.isr.umich.edu/survey-info.php

helpful in explaining future consumer spending (Ludvigson, 2004) and found to be affected by changes in stock market returns (Fisher & Statman, 2003).

– Place Figure 2 and Table 2 here. –

Descriptive statistics are shown in Table 2. Specifically, the average state suicide rate in the United States between 1997 and 2012 is shown in Figure 2. For males of all ages, the average over this time period is 21.06 deaths per 100,000 people. The average rate is far lower amongst females, 4.99 deaths on average. The highest rate during the data period is 62.52 deaths per 100,000, for males aged between 25-64 years. The suicide rate is higher amongst this older age group, for both males and females, 26.60 and 7.38 deaths per 100,000. The suicide rate has risen over time; this is particularly notable from 2007 onwards for all ages and gender. The average suicide rate by state before and after 2007 is shown in Figure 3.

– Place Figure 3 here. –

With the exception of Alaska, the states experiencing the highest suicide rates fall geographically between Montana and New Mexico. The lowest suicide rates are seen in East coast states geographically between Massachusetts and Maryland.

Empirical Methodology

The empirical methodology builds upon a standard dynamic panel data model:

$$y_{it} = \alpha y_{i,t-1} + \boldsymbol{x}_{it}'\boldsymbol{\beta} + \varepsilon_{it}, \text{ where } \varepsilon_{it} = \mu_i + \eta_t + u_{it} \quad (1)$$

Where the random disturbance term, ε_{it}, has three disturbance components: the fixed (state and period) effects, μ_i and η_t, respectively, and idiosyncratic shocks, u_{it}.

The dependent variable, y_{it}, is the log of the suicide rate in the US state i in period t. The advantage of the dynamic panel data model is that it accounts for the possibility that current

values of the dependent variable can be influenced by past ones. Indeed, the coefficient α measures the first-order autoregressive effect of the suicide rate. In the context of our study, unexpected changes to suicide rates today may have long-last effects in the future. It can also be thought to represent the magnitude of adjustment costs in suicidal behaviour.

The row vector $\boldsymbol{x}_{it}{}'$ comprises the explanatory variables. We study the determinants of the suicide rate by means of 4 different models. The benchmark specification (hereinafter Model 1) builds upon Ross et al. (2012) by including per capita state mental health expenditures in logs; per capita public health expenditures in logs; per capita public welfare expenditures in logs; real per capita personal income in logs; net migration as a proportion of the population; civilian unemployment rate; the population density; a mountain state dummy; the divorce rate; and the number of sunny days in a year. However, our study differs from Ross et al. (2012) by focusing on model variants that we present below are suited to test our hypotheses and a different time period (1997 – 2012 in this study against 1997 – 2005 in Ross et al. 2012).

Model 2 replaces in Model 1the time dummies (year fixed effects) by the post-crisis dummy. The crisis dummy takes on value 1 for the years after (and inclusively) 2007 and takes value zero before 2007. The crisis dummy variable supports the notion that the global financial crisis might have had long-last effects on people's mood and hence on the propensity to commit suicide. Another variant, Model 3, is designed to capture the effect of the consumer sentiment index in logs.

The dynamic panel data model as stipulated in Equation (1) can be estimated using panel-data fixed-effects estimation methods, such as a least-squares dummy variable regression, also referred to as a panel ordinary least squares estimator. However, it should be noted that $y_{i,t-1}$ is correlated with the state fixed effect μ_i, which leads to inconsistent estimates of the dynamic

panel data model, if the time series dimension is short. To this end, the dynamic panel data model in Equation (1) is differenced to yield

$$\Delta y_{it} = \alpha \Delta y_{i,t-1} + \Delta \boldsymbol{x}_{it}{}' \boldsymbol{\beta} + \Delta \varepsilon_{it}, \text{ where } \Delta \varepsilon_{it} = \mu_i + u_{it} - \mu_i + u_{i,t-1} = \Delta u_{it} \quad (2)$$

Indeed, differencing eliminates the fixed effect, μ_i. However, the lagged dependent variable $\Delta y_{i,t-1}$ may still be endogenous, since $\Delta y_{i,t-1} = y_{i,t-1} - y_{i,t-2}$ is correlated with $\Delta u_{it} = u_{it} - u_{i,t-1}$. Therefore, instrumenting $\Delta y_{i,t-1}$ and other potentially endogenous explanatory variables with longer lags may yield a consistent estimator of Equation (2).

The difference generalized method of moments (DGMM) estimator, developed by Arellano & Bond (1991), can be used to consistently estimate the model outlined in Equation (2). It builds on the following orthogonality conditions (including the standard assumption on the initial conditions y_{i1}):

$$E\left[y_{is}\left(\Delta y_{it} - \alpha \Delta y_{i,t-1} - \Delta \boldsymbol{x}_{it}{}' \boldsymbol{\beta}\right)\right] = E[y_{is} \Delta u_{it}] = 0 \quad (3a)$$

with $s = 1,2, \dots, t-2;\ t = 3, \dots, T$.

If additionally, the vector $\Delta x_{it}{}'$ comprises strictly exogenous variables, then the following set of orthogonality conditions must be satisfied:

$$E\left[\boldsymbol{x}_{is}\left(\Delta y_{it} - \alpha \Delta y_{i,t-1} - \Delta \boldsymbol{x}_{it}{}' \boldsymbol{\beta}\right)\right] = E[\boldsymbol{x}_{is} \Delta u_{it}] = 0 \quad (3b)$$

with $s, t = 3, \dots, T$.

Equations (3a) and (3b) yield the following moment restrictions that are used by the DGMM estimator to determine the coefficient estimates of Equation (2):

$$E\left(\boldsymbol{Z}'_{i,\boldsymbol{D}} \Delta \bar{\boldsymbol{u}}_{\boldsymbol{i}}\right) = \mathbf{0} \quad (4)$$

where $\boldsymbol{Z_{i,D}}$ is a $(T-2) \times m$ matrix of instruments, dictated by Equations (3a) and (3b), whereas $\Delta\bar{\boldsymbol{u}}_{\boldsymbol{i}}$ is a $(T-2)$ vector of the time-varying disturbances in first differences. More specifically, matrix $\boldsymbol{Z_{i,D}}$ can be expressed as

$$\boldsymbol{Z_{i,D}} = \left\{diag\left[y_{i1}, (y_{i1}, y_{i2}), \dots, \left(y_{i1}, y_{i2}, \dots, y_{i,T-2}\right)\right], (\boldsymbol{x}'_{i3}, \boldsymbol{x}'_{i4}, \dots, \boldsymbol{x}'_{iT})'\right\} \quad (5)$$

Building upon these conditions, the DGMM estimator minimises the following quadratic distance

$$\hat{\gamma}_{DGMM} = \begin{pmatrix} \hat{\alpha} \\ \hat{\boldsymbol{\beta}} \end{pmatrix}_{DGMM} = \underset{\gamma}{\text{argmin}}\, \Delta\bar{\boldsymbol{u}}' \boldsymbol{Z_D A Z'_D}\, \Delta\bar{\boldsymbol{u}} \quad (6)$$

where $\boldsymbol{A}$ is a symmetric matrix, $\Delta\bar{\boldsymbol{u}}' = (\Delta\bar{\boldsymbol{u}}'_{\boldsymbol{1}}, \Delta\bar{\boldsymbol{u}}'_{\boldsymbol{2}}, \dots, \Delta\bar{\boldsymbol{u}}_{\boldsymbol{N}}{}')$ and $\boldsymbol{Z'_D} = \left(\boldsymbol{Z'_{1,D}}, \boldsymbol{Z'_{2,D}}, \dots, \boldsymbol{Z'_{N,D}}\right)$.

It should be recognised that DGMM is subject to a few weaknesses. Indeed, the instruments used in the DGMM estimator become less informative in two important instances; i) as the value of α grows large and approaches unity, and (ii) when the relative variance of the fixed effects, μ_i, increases (Blundell & Bond, 1998, p. 120).

The problem of weak instruments can be ameliorated by using the system GMM (SGMM) estimator, proposed by Arellano & Bover (1995) and completely developed by Blundell & Bond (1998). The SGMM has the following advantages:

First and foremost, system GMM (SGMM) allows some predictors to be predetermined or endogenous. For instance, an unexpected rise in the number of suicides may trigger increases in public expenditures aimed at reducing the suicide rate.

Second, SGMM corrects some of the weaknesses encountered by the difference GMM (DGMM) estimator, developed by Arellano & Bond (1991). Specifically, the SGMM estimator has been demonstrated to have superior performance compared to the DGMM estimator in

terms of finite sample bias and mean square error, as well as standard errors of coefficient estimates (Blundell & Bond, 1998).

The SGMM estimator estimates the system of equations comprising Equation (1) and (2). To this end, in addition to the set of instruments used to estimate Equation (2), the SGMM estimator adds a non-redundant subset of the moment conditions for the level equation, Equation (1). The moment conditions for the SGMM estimator can be written in a compact form as

$$E\left(\widetilde{\boldsymbol{Z}}_i{}'\widetilde{\boldsymbol{u}}_i\right) = \mathbf{0}, \tag{7}$$

where $\widetilde{\boldsymbol{Z}}_i = \left\{diag\left[\boldsymbol{Z}_{i,D}, \boldsymbol{Z}_{i,L}\right]\right\}$, (8)

and where $\boldsymbol{Z}_{i,L} = \left\{diag\left[\Delta y_{i2}, \dots, \Delta y_{i,T-1}\right], (\boldsymbol{\Delta x}'_{i3}, \dots, \boldsymbol{\Delta x}'_{iT})'\right\}$, (9)

and $\widetilde{\boldsymbol{u}}_i = (\Delta\overline{\boldsymbol{u}}'_i, \overline{\boldsymbol{u}}'_i)'$ (10)

In practise, some of the variables in the row vector $\boldsymbol{x}_{it}{}'$ are not strictly exogenous. For instance, unexpected changes in the suicide rate can trigger increases in public funding of mental health, overall health and welfare. We reasonably assume the public authorities might respond to changes in the suicide rate in the same year when they occur and treat these variables as endogenous. Further dividing the vector of the explanatory variables, $\boldsymbol{x}_{it}{}'$, into two sub-vectors of strictly exogenous ($\dot{\boldsymbol{x}}_{it}{}'$) and endogenous ($\boldsymbol{w}_{it}{}'$), so that $\boldsymbol{x}'_{it} = (\dot{\boldsymbol{x}}'_{it}, \boldsymbol{w}'_{\boldsymbol{i1}})$ and Equations (5) and (9) are modified accordingly:

$$\boldsymbol{Z}_{\boldsymbol{i},D} = \left\{diag\left[y_{i1}, \dots, \left(y_{i1}, \dots, y_{i,T-2}\right)\right], diag\left[\boldsymbol{w}'_{i1}, \dots, \left(\boldsymbol{w}'_{i1}, \dots, \boldsymbol{w}'_{i,T-2}\right)\right], (\dot{\boldsymbol{x}}'_{i3}, \dots, \dot{\boldsymbol{x}}'_{iT})'\right\} \quad (5')$$

$$\boldsymbol{Z}_{i,L} = \left\{diag\left[\Delta y_{i2}, \dots, , \Delta y_{i,T-1}\right], diag\left[\Delta\boldsymbol{w}'_{i2}, \dots, \boldsymbol{\Delta w}'_{i,T-1}\right](\Delta\dot{\boldsymbol{x}}_{i3}{}', \dots, \boldsymbol{\Delta}\dot{\boldsymbol{x}}_{iT}{}')'\right\} \tag{9'}$$

We use a two-step SGMM estimator to estimate the population coefficients, $\boldsymbol{\gamma}$. This estimator was developed by Blundell & Bond (1998) as a solution to the problem of heteroscedasticity. In the first step, an initially consistent estimator of the weighting matrix (or the variance and covariance matrix of the two-step GMM estimator), $\boldsymbol{A}$, and hence of the population parameters, $\boldsymbol{\gamma}$, is obtained (see Equation (6)). The second step uses residuals from an initial consistent estimator and produces an asymptotically efficient estimate of the weighting matrix in the class of estimators based on the linear moment conditions (Blundell and Bond 1998). Blundell and Bond (1998) also demonstrate that the two-step SGMM estimator may yield downward-biased results in a finite sample. Indeed, the bias arises from the extra variation due to the presence of estimated parameters in the variance and covariance matrix. To correct for this potential bias, Windmeijer (2005) proposed a finite-sample-corrected estimate of the variance and covariance matrix of the two-step GMM estimator. The finite-sample-corrected efficient weighting matrix is also used in this study.

4. Discussion of Results

4.1. Dynamic Panel Data Models

Results from estimating Models 1 to 3 on state suicide rates between 1997 and 2012 are presented in Tables 3 to 5. Coefficient estimates are indicated as statistically significant by asterisks. Standard errors are clustered by state. Fixed effects, where used, are not reported (see table footnotes).

Table 3 shows results from Model 1, this is the base model, closely following the specification shown in Ross et al. (2012). Table 4 shows the results from Model 2 that includes a financial crisis pulse variable (from 2007 onwards), testing hypothesis 2: The onset of the 2007 financial

crisis in the USA increased the suicide rate. Similarly, Table 5 shows results from Model 3 which include the Consumer Sentiment Index to test hypothesis 3: The CSI scores are inversely related to the suicide rate. In each model, the lagged dependent variable measures the state suicide rate in the previous time period and has a significant impact on changes in suicide rates during the current time period, especially for males, showing a long-lasting effect of previous suicide rates.

– Place Table 3 here. –

– Place Table 4 here. –

– Place Table 5 here. –

Hypothesis 1: Higher mental health expenditure reduces suicides

The log of per capita state mental health expenditures is included in all model specifications and we find no evidence to support the hypothesis that mental health expenditure reduces suicide rates. This lack of support for a relationship between state expenditures and suicide rates refutes the evidence shown by Minoiu & Rodríguez Andrés (2008) for US states between 1982 and 1997. However, this is in line with results from Ross et al. (2012) who provide a re-investigation of on the grounds that Minoiu & Rodríguez Andrés (2008) measure public health and welfare spending as a share of total state expenditures rather than a more refined of absolute or per capita expenditure.

One of the missions the National Association of State Mental Health Program Directors strive for is ‘zero suicide’. Our results suggest that an increase in public mental health spending is

unlikely to reduce the suicide rate in the United States. Indeed, as posited by Burgess et al. (2004), Shah et al. (2010), Rajkumar et al. (2013) and others, suicides can be triggered by social factors and not mental health issues. Hence, more spending on mental health is unwarranted and displaces potentially more effective spending elsewhere.

Economic and demographic measures

Personal income has only a statistically significant impact on suicide rates amongst males aged 25-64 years, where a 10 per cent increase in real per capita personal income reduces state suicide rates by 15.9 per cent. Hamermesh & Soss (1974) postured that suicide appears a more likely option for those who consider their lifetime utility to fall below a certain threshold. In this context, higher income provides greater resources to support lifetime satisfaction (or utility) and hence reduces suicide rates.

However, the civilian unemployment rate shows little influence on suicide rates, as found by Ross et al. (2012). The exception being: i) a counter intuitive finding that rise in unemployment leads to a small reduction in suicide rates for Males aged 25-64 in Model 1 (Table 3); ii) a rise in unemployment leads to a small increase in the suicide rate for Males in Model 2 (Table 4) and Model 3 (Table 5). The results show no consistent evidence to support a relationship between traditional economic performance indicators (income and unemployment) and suicide rates. This runs counter to the relationship postured by Pierce (1967) that suicide rates are influenced by the economic cycle. We posit that individuals' perceptions of their own financial situation and of the general economy in near and long term are, rather than macroeconomics measures of unemployment or income, can better identify changes in suicide rates. This is further explored in relation to Hypothesis 3, discussed below.

Results show that an increase in the divorce rate by one unit increases the suicide rate by 1.7 and 3.1 percent for males in Model 3 and Model 2, respectively, whereas females (all) appear unaffected. This provides some (weak) support for the notion that divorce can increase suicide rates through reduced social integration and family ties al a Durkheim (1987). Whilst we do not formally test for the relationship, it is interesting to note that in the presence of the financial crisis pulse variable (Model 2), the impact of divorce rate increases for males. Reflecting in a more speculative vein, this might suggest that the influence of divorce on suicide rates for males was greater during the financial crisis.

An increase in net migration or a reduction in population density might be expected to increase suicide rates through the mechanism of reduced social integration, however, results show that migration is only significant in one specification (Model 2). Here an increase in migration increases the suicide rate for females. We do, however, find evidence to show that an increase in the non-white population reduces suicide rates for males (Model 2). This aligns with the conjecture by Ross et al. (2012). This relates to the argument that minority groups may work harder on social connections, thus depressing suicidal tendencies.

Geographic measures

Whilst these results do not show evidence that a greater number of days of sunshine in a year reduces the suicide rate, there is evidence to show that living in a mountain state increases the suicide rate by between 1.7 and 26.8 per cent. From Models 2 and 3, the impact of living in a mountain state is generally larger for females. As with population density, results regarding

these bioclimatic factors are also supported by Minoiu & Rodríguez Andrés (2008) and Ross et al. (2012).[3]

Hypothesis 2: The onset of the 2007 financial crisis in the USA increased the suicide rate

Model 2 (Table 4) includes the post-crisis pulse variable from 2007 onwards. Suicide rates are 2.1 per cent higher after the financial crisis, using all sex and age groups. Notably, the crisis had a greater impact on females, triggering an increase in female suicide rates by 6.0 per cent.

Hypothesis 3: Higher Consumer Sentiment Index (CSI) scores indicate a lower suicide rate

The Consumer Sentiment Index is a measure of consumers' perceptions of their personal financial situation and of the economy in general. Estimates for Model 3, Table 5, show that a 10 per cent increase in the CSI reduces suicide rates by 1.0 per cent confirming that a more positive consumer outlook reduces suicide rates. This effect is greater for females (1.8 per cent) than males (1.2 per cent). An increase in consumer sentiment makes people more optimistic, which dissuades them from engaging in suicidal behaviour. By contrast, a decrease in consumer sentiment can trigger suicidal behaviour through a variety of mechanisms, as indirectly suggested by Haw et al. (2015). Consumers become more pessimistic when they anticipate periods of financial hardship, which is associated with loss of savings, higher household debt levels, house repossession, and bankruptcy. Thus, a decrease in consumer sentiment can trigger

[3] We exploit further geographic measures in our study. Cheaper medication available in Mexico and better healthcare infrastructure in Canada should reduce the potential of suicidal behaviour. Building upon Model 1, Model 6 (not reported) further seeks to identify the border effect on the suicide rate. To this end, using data on the proximity of the state to the Northern and Southern US borders from the World Atlas (2015), we construct two dummy variables, NORTH and SOUTH, which take value 1 if the state shares border with Canada and Mexico, respectively, and take value 0 otherwise. We find that the border effect is negative and significant for working-age males living in the Southern border states. Thus, cheaper medication and services in Mexico may act as a suicide gatekeeper. Results are not reported but are available from the authors upon request.

relationship ruptures and social isolation which are potentially conducive to higher suicidal intent.

4.2. Robustness Exercise

Because the suicide rate can be measured as a proportion, models with a beta link function can be tailored to ensure that the suicide is confined to the interval (0,1). Therefore, as a robustness exercise, we also estimate beta regression with a logit link function, in which the suicide rate is calculated as the number of deaths per 100,000 inhabitants divided by 100. We estimate beta regression including the financial crisis dummy (Table 6, Model 4) and the consumer sentiment index (Table 7, Model 5).

– Place Table 6 here. –

– Place Table 7 here. –

Like the Model 2 (Table 4) estimate, in Model 4 the suicide rate was higher in the post-crisis period than in the pre-crisis period, *ceteris paribus*. Further, consistent with the estimate of Model 3 (Table 5), in Model 5, we find that the consumer sentiment index has a negative effect on the suicide rate. As in Models 1 to 3, the effect of mental health expenditure remains insignificant for both Models 4 and 5.

5. Summary and Concluding Remarks

Overall, our research findings do not appear to support the hypothesis that higher mental health expenditure reduces suicides. We also find that the average suicide rate increased significantly in the aftermath of the financial crisis for all sex and age groups, wherein the effect was stronger for females than for males. Moreover, our research findings identify an inverse relation

between the consumer sentiment index – a measure of consumer's perceptions of their financial situation and of the economy in general – and the average suicide rate. These research findings contribute to the quest for optimal, or at least broadly appropriate, policy interventions.

This study uses a two-step SGMM estimator to model the influence of traditional socioeconomic determinants as well as factors that are more contemporary public foci on state level suicide rates in the USA, from 1997 to 2012. This method provides an estimated causal influence of these selected factors on the rate of suicides. All three model specifications tested and reported in this study show no evidence to support the hypothesis that mental health expenditure reduces suicide rates. As such, the hypothesis that that mental health expenditure has no influence on suicide rates cannot be rejected, in line with the findings of Ross *et al* (2012).

However, contributing to development of a better predictive model, using more subjective economic indicators provide a clearer understanding of the fluctuations in suicide rates. The economic shock of the financial crisis, described by a pulse variable from 2007 onwards, has a statistically significant impact on suicide rates. Results show that a more positive consumer outlook on personal finance and the economy in general, as measured by the Consumer Sentiment Index, lowers the suicide rate. We also find that the effect of consumer sentiment is greater for females than for males.

Taken together, these results pose some awkward questions for policymakers, especially in the context of justifying state mental health expenditure budgets in the USA and communicating economic policy that affects consumers. Problematically, it seems that Treasury and Federal Reserve signals and actions that affect broader consumer sentiment should at least be recognised as sources of potential mental health spillover effects. Furthermore, whilst this study did not disaggregate further mental health expenditure in order to explore the specific

contributions of particular sub-categories of mental health spending, such further scrutiny is indeed warranted. This would help identify, at least in relative terms, the most effective interventions. Additionally, such disaggregation might also provide some better guidance to state-level policy. The wide variations in mean suicide rates shown in Figure 3 may potentially be narrowed by some states benchmarking to the most 'comparable' states with the lowest mean suicide rates.

References

Antonakakis, N., & Collins, A., (2014). The impact of fiscal austerity on suicide: On the empirics of a modern Greek tragedy. *Social Science & Medicine*, *112*, 39-50.

Antonakakis, N., & Collins, A. (2015). The impact of fiscal austerity on suicide mortality: Evidence across the 'Eurozone periphery'. *Social Science & Medicine*, *145*, 63-78.

Antonakakis, N., & Collins, A., (2018). A suicidal Kuznets curve? *Economics Letters*, *166*, 90-93.

Arellano, M., & Bond, S. (1991). Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *Review of Economic Studies*, *58*, 277-297.

Arellano, M., & Bover, O. (1995). Another look at the instrumental variable estimation of error-components models. *Journal of Econometrics*, *68*, 29-51.

Barsky, R.B., & Sims, E.R., (2012). Information, animal spirits, and the meaning of innovations in consumer confidence, *American Economic Review*, *102*(4), 1343-77.

Berk, M., Dodd, S. & Henry, M. (2006). The effect of macroeconomic variables on suicide. *Psychological Medicine*, *36*, 181-189.

Blundell, R., & Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics*, *87*, 115-143.

Bovi, M., (2009). Economic versus psychological forecasting. Evidence from consumer confidence surveys", *Journal of Economic Psychology*, *30*(4), 563-574.

Burgess, P., Pirkis, J., Jolley, D., Whiteford, H., & Saxena., S. (2004). Do nations' mental health policies, programs and legislation influence their suicide rates? An ecological study of 100 countries. *Australian and New Zealand Journal of Psychiatry*, *38*(11-12), 933–939

Centers for Disease Control and Prevention (CDC), (2015)., Faststats – *Suicide and Self-Inflicted Injury* Retrieved on 26/07/2015 http://www.cdc.gov/nchs/fastats/suicide.htm

Chelminski, P., & Coulter, R.A., (2007). On market mavens and consumer self-confidence: A cross-cultural study, *Psychology & Marketing*, *24*(1), 69-91.

Chen, J., Choi, Y. J., Mori, K., Sawada, Y., & Sugano, S., (2012). Socio-Economic Studies on Suicide: A Survey. *Journal of Economic Surveys*, *26*(2), 271-306.

Chicone, L. E. (2017). Homicides in Mexico and the expiration of the U.S. federal assault weapons ban: a difference-in-discontinuities approach. *Journal of Economic Geography*; first published online January 12, 2017 doi:10.1093/jeg/lbw031.

Dunn, R. (2008). The Role of Air Pollution in Domestic Mobility. West Virginia University Department of Economics Working Paper Series.

Durkheim, E. (1897). *Le Suicide: Etude de Sociologie*. Alcan, Paris. (Spaulding, J.A., Simpson, G (Trans.), 1951. Suicide: A Study of Sociology). Free Press, New York.

Anderson, D.M., Rees, D.I. & Sabia, J.J. (2014). Medical marijuana laws and suicides by gender and age. *American Journal of Public Health*, *104*(12), pp.2369-2376.

Fajnzylber, P., Lederman, D. & Loayza, N., 2002. What causes violent crime? *European Economic Review*, *46*(7), pp.1323-1357.

Fernquist, R.M., (2003). Does the level of divorce or religiosity make a difference? Cross-national suicide rates in 21 developed countries, 1955-1994. *Archives of Suicide Research*, *7*(3), 265-277.

Fisher, K. L., & Statman, M. (2003). Consumer confidence and stock returns. *Journal of Portfolio Management*, *30*(1), 115-127.

Gausden, R. and Hasan, M.S., (2016), Would information on consumer confidence have helped to predict UK household expenditure during the recent economic crisis?, *Applied Economics*, *48*(18), 1695-1709.

Härkönen, J. and Dronkers, J., (2006). Stability and change in the educational gradient of divorce. A comparison of seventeen countries. *European Sociological Review*, *22*(5), 501-517.

Haw, C., Hawton, K., Gunnell, D., Platt, S., (2015), Economic recession and suicidal behaviour: Possible mechanisms and ameliorating factors. *International Journal of Social Psychiatry*, *61*(1), 73-81.

Knapp, M. (2012). Mental Health in an Age of Austerity. *Evidence Based Mental Health*, *15*, 54-55.

Lemmon, M. & Portniaguina, E. (2006). Consumer confidence and asset prices: Some empirical evidence. *The Review of Financial Studies*, *19*(4), 1499-1529.

Ludvigson, S. C. (2004). "Consumer confidence and consumer spending." *Journal of Economic Perspectives*, *18*(2), 29-50.

Ludwig, J., Marcotte, D. E., & Norberg, K. **(**2009). Anti-depressants and suicide. *Journal of Health Economics*, *28*(3), 659-676.

Minoiu, C., & Rodríguez Andrés, A. (2008). The effect of public spending on suicide: evidence from U.S. state data. *Journal of Socio-Economics, 37* (1), 237–261.

Pierce, A., (1967). The economic cycle and the social suicide rate. *American Sociological Review*, 32(3), 457-462.

Phillips, J.A., (2013). Factors associated with temporal and spatial patterns in suicide rates across US states, 1976–2000. *Demography, 50*(2), 591-614.

Platt, S., (1984). Unemployment and suicidal behaviour: a review of the literature, *Social Science & Medicine*, *19*(2), 93-115.

Rajkumar, A. P., Brinda, E. M., Duba, A. S., Thangadurai, P., & Jacob, K. S**. (**2013). National suicide rates and mental health system indicators: An ecological study of 191 countries. *International Journal of Law and Psychiatry*, *36*(5), 339-342.

Reeves, A., Stuckler, D., McKee, M., Gunnell, D., Chang, S. S., & Basu, S. **(**2012). Increase in state suicide rates in the USA during economic recession. *The Lancet*, *380*(9856), 1813-1814.

Rosenfeld, R. and Fornango, R., (2007). The impact of economic conditions on robbery and property crime: the role of consumer sentiment, *Criminology, 45*(4), 735-769.

Rosenfeld, R., (2009). Crime is the problem: Homicide, acquisitive crime, and economic conditions, *Journal of Quantitative Criminology*, *25*(3), 287-306.

Ross, J., Yakovlev, P. & Carson, F. (2012). Does state spending on mental health lower suicide rates. *Journal of Socio-Economics*, *41*(4), 408-417.

Ruhm, C.J. **(**2003). Good times make you sick. *Journal of Health Economics,* 22(4), 637-658,

Ruhm, C.J. (2015). Recessions, healthy no more? *Journal of Health Economics*, *42*, 17-28,

Shah, A., Bhandarkar, R., & Bhatia, G. 2010. "The relationship between general population suicide rates and mental health funding, service provision and national policy: a cross-national study." *International Journal of Social Psychiatry*, *56*(4), 448-453.

Spreng, R.A. & Page Jr, T.J. (2001). The impact of confidence in expectations on consumer satisfaction, *Psychology & Marketing*, *18*(11), 1187-1204.

Stack, S. (1982). Suicide: A decade review of the sociological literature, *Deviant Behavior*, *4*(1), 41-66.

Stack, S. (2000a). Suicide: a 15-year review of the sociological literature part I: cultural and economic factors. *Suicide and Life-Threatening Behavior*, *30*(2), 145-162.

Stack, S. (2000b). Suicide: a 15-year review of the sociological literature part II: modernization and social integration perspectives. *Suicide and Life-Threatening Behavior*, *30*(2), 163-176.

Tefft, N. (2011). Insights on unemployment, unemployment insurance, and mental health. *Journal of Health Economics*, *30*(2), 258-264.

Windmeijer, F. (2005). A finite sample correction for the variance of linear efficient two-step GMM estimators. *Journal of Econometrics*, *126*, 25-51.

Yang, B. (1992). The economy and suicide: A time-series study of the USA, *American Journal of Economics and Sociology*, *51*(1), pp.87-99.

Table 1. Variable definitions and sources

Variable	Definition	Source
Suicide Rates	**Suicide rates (deaths per 100,000 people)**	
Male, all	Male age-adjusted suicide rate for entire male population	Centers for Disease Control WISQARS Injury Mortality Reports.
Male, 25–64	Male age-adjusted suicide rate for population aged 25-64	
Female, all	Female age-adjusted suicide rate for entire female population	
Female, 25–64	Female age-adjusted suicide rate for population aged 25-64	
State expenditure	**Real per capita public expenditures (in 2000 USD)**	
Mental health	State Mental Health Agency expenditures	National Association of State Mental Health Program Directors Research Institute
Public welfare	Public welfare expenditures	U.S. Census Bureau
Public health	Public health expenditures	U.S. Census Bureau
Demographic and Economic measures		
Income	Real per capita personal income (in 2000 USD)	Bureau of Economic Analysis
Migration	Net migration as a proportion of population	U.S. Census Bureau
Unemployment	Civilian unemployment rate	Bureau of Labor Statistics
Population density	Population density	U.S. Census Bureau
Divorce	Divorce rate	U.S. Census Bureau
Non-white	Share of the population that is non-white	U.S. Census Bureau
Financial crisis	Post-2007 financial crisis dummy	Authors' Created
Consumer Sentiment Index	Quantifies consumers' perceptions of their own financial situation and of the general economy in near and long term (1996 = 100)	Thomson Reuters Datastream University of Michigan, Surveys of Consumers
Geographic measures		
Mountain state	Mountain state dummy (indicates whether the state is located in the Rocky Mountain Census Region)	U.S. Census Bureau
Days of sunshine	Number of sunny days in a year	Dunn (2008)

Notes: Table 1 defines the variables used in our study, and describes the sources of data.

Table 2. Descriptive statistics, and expectations

Variable	**Descriptive statistics**					**Expected**
Suicide Rates	**Obs**	**Mean**	**Sdev**	**Min**	**Max**	**sign**
Male, all	816	21.06	5.90	6.20	48.12	
Male, 25–64	816	26.60	7.27	6.59	62.52	
Female, all	816	4.99	1.67	1.22	11.27	
Female, 25–64	815	7.38	2.53	1.20	17.61	
State expenditure						
Mental health	816	89.68	59.83	10.90	401.24	–
Public welfare	816	1060.58	426.80	264.23	3025.96	–
Public health	816	157.21	95.44	0.00	654.77	–
Demographic and Economic measures						
Income	816	29572.99	5209.24	19849.04	57756.07	–
Migration	816	0.00	0.01	-0.02	0.04	+
Unemployment	816	5.64	2.50	2.30	46.00	+
Population density	816	362.89	1295.68	0.93	10357.70	–
Divorce	813	4.01	1.04	0.80	10.40	+
Non-white	816	0.19	0.13	0.03	0.75	–
Financial crisis	816	0.38	0.48	0.00	1.00	+
Consumer Sentiment Index	816	86.88	13.98	63.80	107.50	–
Geographic measures						
Mountain state	816	0.16	0.36	0.00	1.00	+
Days of sunshine	816	147.19	36.81	56.60	248.40	+/–

Notes: Table 2 reports the descriptive statistics of the variables employed in our study. Obs = number of observations, Mean = sample average, Sdev = sample standard deviation, Min = minimum sample value, Max = maximum sample value. This table also outlines the expected sign for the effects of the explanatory variable on the dependent variable.

Table 3. Model 1: DPD two-step SGMM estimation - Ross et al. (2012) specification

	All	**Male, all**	**Male, 25–64**	**Female, all**	**Female, 25–64**
Lagged dependent variable	0.4749***	0.5654***	0.4516*	0.2813	0.2202
State expenditures (natural logarithm)					
Mental health	-0.1424	0.0288	0.1041	-0.1867	0.0637
Public welfare	-0.0472	0.0650	0.1585	-0.0061	0.3763
Public health	0.0177	-0.0100	-0.0149	0.0526	0.1495
Demographic and economic measures					
Income (natural logarithm)	-0.7640*	-0.3186	-1.5905*	-0.9634	-2.7768
Migration	-0.0042	-2.8945	-3.3653	3.8273	-0.1227
Unemployment	-0.0051*	-0.0027	-0.0098*	-0.0062	-0.0155
Population density	0.0000	-0.0002	0.0002	0.0001	0.0002
Divorce	-0.0054	0.0223*	0.0081	0.0081	0.0145
Non-white	0.0298	-0.0376	-0.0433	-0.1856	-0.3522*
Geographic measures					
Mountain state	0.1863**	0.1570*	0.2471**	0.2499	0.3141*
Days of sunshine	-0.0013**	0.0001	-0.0001	-0.0016	-0.0002
R-squared	0.731	0.847	0.593	0.534	0.315
Arellano-Bond AR(1)	0.001	0.001	0.008	0.031	0.003
Arellano-Bond AR(2)	0.010	0.062	0.119	0.322	0.139
Sargan	0.916	0.612	0.895	0.855	0.535
Hansen	1.000	1.000	1.000	1.000	1.000

Notes: Table 3 reports the system GMM estimates of the dynamic panel data model (DPD) (Model 1), which replicates the specification of Ross et al. (2012) but adds more recent data. In column "All", the dependent variable in the DPD is the average suicide rate in the whole population at all ages. In column "Male, All", the dependent variable is the suicide rate for males of all ages. In column "Male, 25-64", the dependent variable is the suicide rate for working age males. In column "Female, All", the dependent variable is the suicide rate for females of all ages. In column "Female, 25-64", the dependent variable is the suicide rate for working age females. Standard errors are clustered by state. Deep lags of dependent variable and the three expenditure variables are treated as endogenous. Year fixed effects are estimated but not reported. For the Arellano-Bond, Sargan and Hansen tests p-values are reported. *** Significant at the 1% level. ** Significant at the 5% level. * Significant at the 10% level.

Table 4. Model 2: DPD two-step SGMM estimation - Inclusion of a financial crisis pulse variable (2007 onwards)

	All	**Male, all**	**Male, 25–64**	**Female, all**	**Female, 25–64**
Lagged dependent variable	0.7907***	0.7107***	0.6619***	0.4053***	0.3891***
State expenditures (natural logarithm)					
Mental health	0.0105	0.0588	0.0056	0.0000	-0.0959
Public welfare	0.0281	-0.0422	0.0080	0.0940	0.2395*
Public health	-0.0135	0.0172	0.0409	-0.0103	0.0275
Demographic and economic measures					
Financial crisis	0.0213**	0.0314***	0.0452***	0.0600**	0.0712**
Income (natural logarithm)	0.0914	0.2041	0.1560	0.0430	0.0508
Migration	2.6785	2.0581	2.9532	8.6974*	2.9001
Unemployment	0.0011	0.0029*	0.0018	0.0012	0.0048
Population density	-0.0000	-0.0001	-0.0001	-0.0001	-0.0001
Divorce	0.0126	0.0313**	0.0213	0.0257	0.0434
Non-white	-0.0534**	-0.1352**	-0.1723**	0.3884	-0.0404
Geographic measures					
Mountain state	0.0656	0.0536	0.0786	0.2433***	0.2619**
Days of sunshine	-0.0002	0.0001	-0.0001	- 0.0006	-0.0005
Constant	-0.6119	-1.4180	-0.8505	-0.2651	-0.8766
R-squared	0.879	0.805	0.759	0.660	0.630
Arellano-Bond AR(1)	0.000	0.000	0.000	0.001	0.001
Arellano-Bond AR(2)	0.014	0.055	0.033	0.133	0.051
Sargan	0.928	0.728	0.888	0.918	0.685
Hansen	1.000	1.000	1.000	1.000	1.000

Notes: Table 4 reports the system GMM estimates of the dynamic panel data model (DPD) (Model 2, which adds the financial crisis pulse dummy ("Financial crisis") to Model 1. In column "All", the dependent variable in the DPD is the average suicide rate in the whole population at all ages. In column "Male, All", the dependent variable is the suicide rate for males of all ages. In column "Male, 25-64", the dependent variable is the suicide rate for working age males. In column "Female, All", the dependent variable is the suicide rate for females of all ages. In column "Female, 25-64", the dependent variable is the suicide rate for working age females. Standard errors are clustered by state. Deep lags of dependent variable and the three expenditure variables are treated as endogenous. Crisis is a dummy variable = 1 from 2007 onwards. For the Arellano-Bond, Sargan and Hansen tests p-values are reported. *** Significant at the 1% level. ** Significant at the 5% level. * Significant at the 10% level.

Table 5. Model 3: DPD two-step SGMM estimation - Inclusion of a consumer sentiment index

	All	**Male, all**	**Male, 25–64**	**Female, all**	**Female, 25–64**
Lagged dependent variable	0.7820***	0.7208***	0.6735***	0.4697***	0.3820***
State expenditures (natural logarithm)					
Mental health	-0.0993	-0.0186	-0.0194	-0.0007	-0.0460
Public welfare	0.0358	-0.0087	-0.0086	0.0670	0.2684**
Public health	0.0237	-0.0079	0.0361	-0.0254	0.0172
Demographic and economic measures					
Consumer Sentiment Index (natural logarithm)	-0.1015***	-0.1156***	-0.1115**	-0.1766**	-0.2151**
Income (natural logarithm)	0.1362	0.1073	0.2118	0.1672	-0.1775
Migration	1.4904	1.7690	4.2874	6.6212	3.6753
Unemployment	0.0008	0.0020***	0.0006	0.0024	0.0040
Population density	-0.0000	-0.0000	-0.0001	-0.0001	-0.0001
Divorce	0.0095	0.0179**	0.0137	0.0348	0.0437
Non-white	-0.0649*	-0.0890	0.1161	0.1635	-0.0209
Geographic measures					
Mountain state	0.0693**	0.0179*	0.0838	0.2107***	0.2677***
Days of sunshine	-0.0005	-0.0003	-0.0002	-0.0006	-0.0003
Constant	-0.2953	0.4032	-0.6997	-0.5633	2.0753
R-squared	0.865	0.851	0.736	0.676	0.633
Arellano-Bond AR(1)	0.000	0.000	0.000	0.001	0.001
Arellano-Bond AR(2)	0.024	0.051	0.039	0.137	0.071
Sargan	0.959	0.778	0.998	0.930	0.706
Hansen	1.000	1.000	1.000	1.000	1.000

Notes: Table 5 reports the system GMM estimates of the dynamic panel data model (DPD) (Model 3), which adds the Consumer Sentiment Index to Model 1. In column "All", the dependent variable in the DPD is the average suicide rate in the whole population at all ages. In column "Male, All", the dependent variable is the suicide rate for males of all ages. In column "Male, 25-64", the dependent variable is the suicide rate for working age males. In column "Female, All", the dependent variable is the suicide rate for females of all ages. In column "Female, 25-64", the dependent variable is the suicide rate for working age females. Standard errors are clustered by state. Deep lags of dependent variable and the three expenditure variables are treated as endogenous. For the Arellano-Bond, Sargan and Hansen tests p-values are reported. *** Significant at the 1% level. ** Significant at the 5% level. * Significant at the 10% level.

Table 6. Model 4: Beta regression / logit model estimation - Inclusion of a financial crisis pulse variable (2007 onwards)

	All	**Male, all**	**Male, 25–64**	**Female, all**	**Female, 25–64**
State expenditures					
Mental health	0.0003	0.0005*	0.0002	-0.0001	-0. 0002
Public welfare	0.0001***	0.0001***	0.0002***	0.0002***	0.0002***
Public health	-0.0001	-0.0002	-0.0000	-0.0001	-0.0001
Demographic and economic measures					
Financial crisis	0.1301***	0.1307***	0.2007***	0.1602***	0.2008***
Income	-0.0000***	-0.0000***	-0.0000***	-0.0000***	-0.0000***
Migration	5.9155***	5.2453***	6.6357***	9.8423***	10.9349***
Unemployment	0.0015	0.0010	0.0049*	0.0033	0.0059
Population density	-0.0001***	-0.0001***	-0.0001***	-0.0001***	-0.0001***
Divorce	0.0720***	0.0794***	0.0658***	0.0669***	0.0649***
Non-white	-0.2366***	-0.3321***	-0.3755***	0.0371	-0.1094
Geographic measures					
Mountain state	0.3806***	0.4202***	0.4249***	0.3781***	0.3610***
Days of sunshine	-0.0010***	-0.0011***	-0.0010***	-0.0009***	-0.0008**
Constant	-1.7243***	-1.0219***	-0.7451***	-3.1820***	-2.6824***
Wald test (Chi-Square)	1731.83***	1672.67***	1506.15***	1210.34***	1150.42***

Notes: Table 6 reports estimates of the beta regression (logit model), which includes the Consumer Sentiment Index to Model 1. In column "All", the dependent variable in the logit is the suicide in the whole population at all ages. In column "Male, All", the dependent variable is the suicide proportion for males of all ages. In column "Male, 25-64", the dependent variable is the suicide proportion for working age males. In column "Female, All", the dependent variable is the suicide proportion for females of all ages. In column "Female, 25-64", the dependent variable is the suicide proportion for working age females. The joint significance of the explanatory variables is tested by means of the Wald test. Robust standard errors are reported. *** Significant at the 1% level. ** Significant at the 5% level. * Significant at the 10% level.

Table 7. Model 5: Beta regression / logit model estimation - Inclusion of a consumer sentiment index

	All	**Male, all**	**Male, 25–64**	**Female, all**	**Female, 25–64**
State expenditures					
Mental health	0.0004	0.0005*	0.0002	-0.0000	-0.0002
Public welfare	0.0001***	0.0001***	0.0002***	0.0002***	0.0002***
Public health	-0.0001	-0.0002*	-0.0000	-0.0001	-0.0001
Demographic and economic measures					
Consumer Sentiment Index	-0.0042***	-0.0042***	-0.0070***	-0.0055***	-0.0072***
Income	-0.0000***	-0.0000***	-0.0000***	-0.0000***	-0.0000***
Migration	5.7994***	5.1393***	6.2502***	9.6851***	10.6322***
Unemployment	0.0015	0.0011	0.0042	0.0030	0.0051
Population density	-0.0001***	-0.0001***	-0.0001***	-0.0001***	-0.0001***
Divorce	0.0733***	0.0806***	0.0688***	0.0689***	0.0681***
Non-white	-0.2246	-0.3197***	-0.3626***	0.0516	-0.0970
Geographic measures					
Mountain state	0.3817***	0.4215***	0.4244***	0.3787***	0.3600***
Days of sunshine	-0.0010***	-0.0011***	-0.0010***	-0.0009***	-0.0008***
Constant	-1.3181***	-0.6226***	-0.0581	-2.6564***	-1.9820***
Wald test (Chi-Square)	1747.85***	1680.50***	1485.33***	1244.90***	1195.24***

Notes: Table 7 reports estimates of the beta regression (logit model), which includes the Consumer Sentiment Index to Model 1. In column "All", the dependent variable in the logit is the suicide in the whole population at all ages. In column "Male, All", the dependent variable is the suicide proportion for males of all ages. In column "Male, 25-64", the dependent variable is the suicide proportion for working age males. In column "Female, All", the dependent variable is the suicide proportion for females of all ages. In column "Female, 25-64", the dependent variable is the suicide proportion for working age females. Robust standard errors are reported. The joint significance of the explanatory variables is tested by means of the Wald test. *** Significant at the 1% level. ** Significant at the 5% level. * Significant at the 10% level.

Figure 1. Research approach.

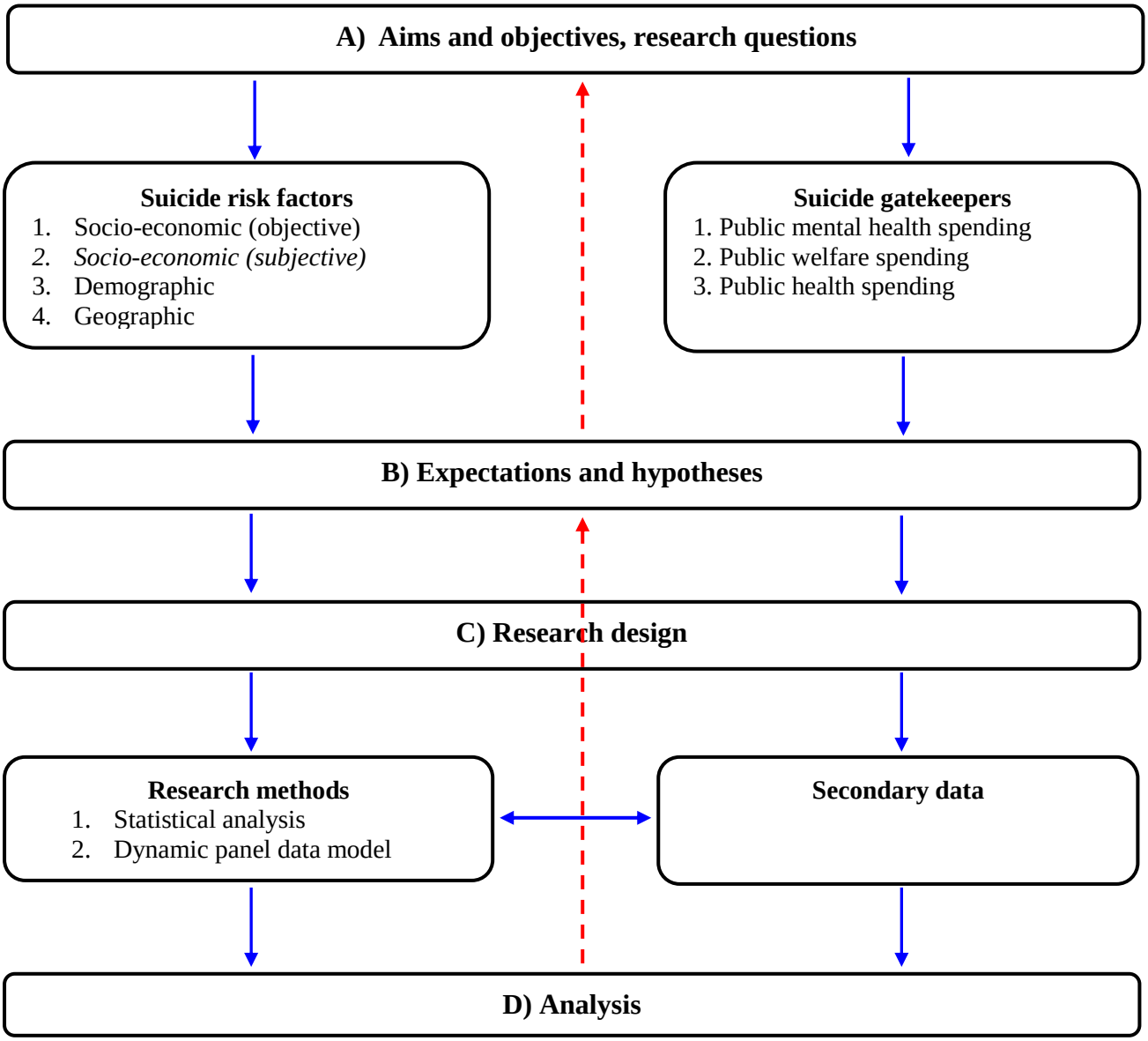

Figure 2. Variation over time of mean suicide rate by gender and age.

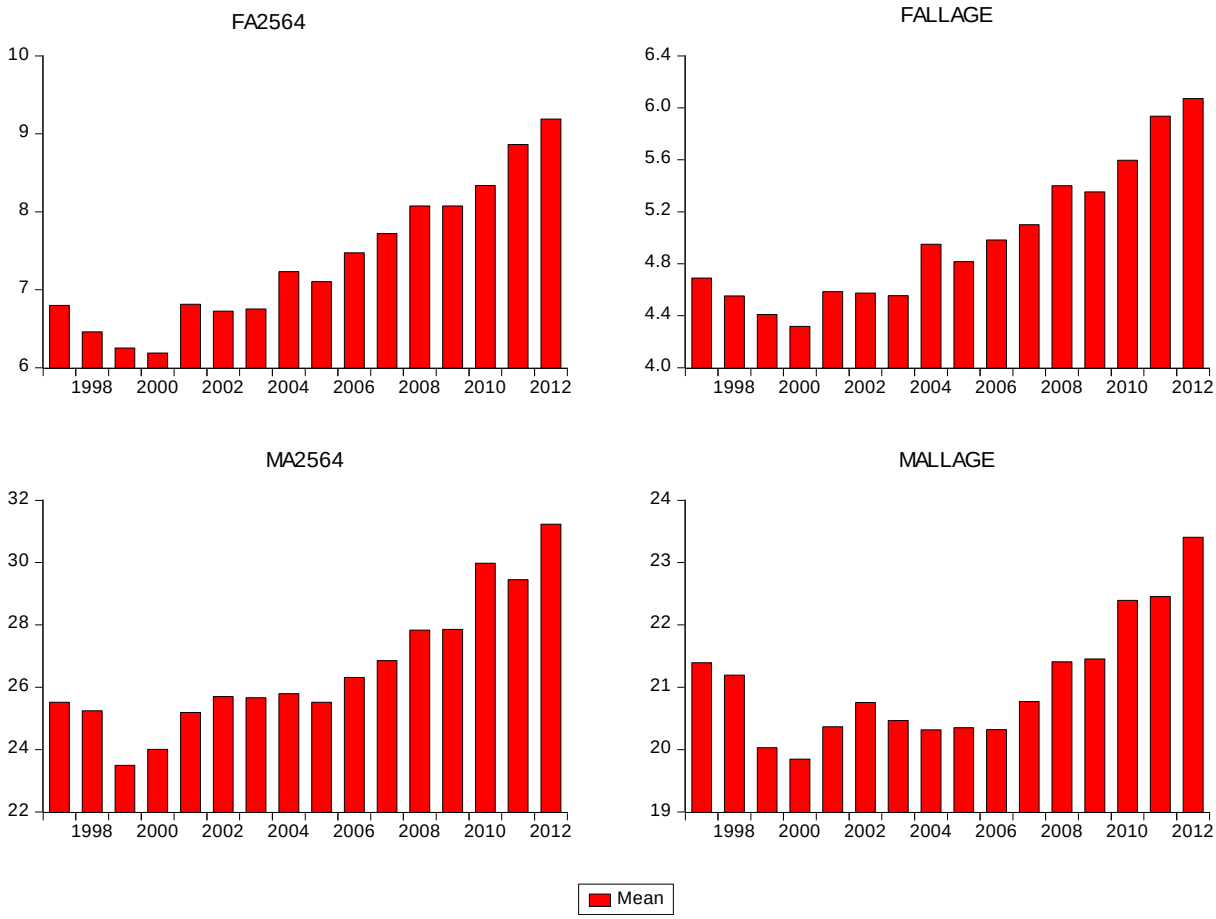

Figure 3. Mean suicide rate by state, before and after the 2007 financial crisis